



Effect of organic amendments on the productivity and quality of produce and soil in groundnut (*Arachis hypogaea*)-onion (*Allium cepa*) cropping system

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ABSTRACT

Field experiments was conducted during 2010-12 at Bangalore to study the effect of sources on the quality of soil, crop and sustainability of yield in groundnut (*Arachis hypogaea* L.) onion (*Allium cepa* L.) cropping system involving biodigested liquid organic manure (BDLM), enriched biodigested liquid organic manure (EBDLM), cow urine (CU) vis-a-vis recommended doses of fertilizers for irrigated groundnut (FYM at 10 tonnes + 25:75:37.5 kg N:P₂O₅:K₂O/ha) and onion (FYM at 30 tonnes + 125:50:75 kg N:P₂O₅:K₂O/ha) with three foliar sprays of panchagavya (PG) and vermiwash (3 percent) at 30, 60 and 75 days after sowing. Application of EBDLM at 25 kg N equivalent/ha + 3 sprays of 3% PG for groundnut, EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3% for onion registered significantly higher organic carbon content and available nitrogen, phosphorus, potassium and sulphur (0.63%, 355.2, 78.30, 190.8 and 36.3 kg/ha, respectively) and significantly more number of bacteria (32.58×10^6 CFU / g of soil), fungi (21.77×10^3 CFU/g of soil) and actinomycetes (12.28×10^3 CFU/g of soil) after the harvest of second crop in groundnut-onion sequence cropping system. Pod yield of groundnut (2335 kg/ha) and bulb yield of onion (37.78 tonnes/ha) were significantly higher with the application of EBDLM at 25 kg N equivalent/ha + 3 sprays of PG at 3% (groundnut)/EBDLM at 125 kg N equivalent/ha + 3 sprays of 3% PG (onion). Sustainability yield index was also higher with above treatment (0.90 and 0.89 for groundnut and onion, respectively). Quality parameters like oil and protein yield (875 and 364 kg /ha, respectively) in groundnut and total soluble solids, reducing, non-reducing sugars, ascorbic and pyruvic acid (16.93, 3.66, and 8.66%, 25.27 mg 100/g and 12.82 μ moles/g, respectively) of onion bulb were significantly superior with above treatment.

Key words: Microbial population, Organic amendments soil health, Quality, Soil fertility, Sustainability

Groundnut and onion are the most important commercial crops grown in Karnataka with an area of 8.5 lakh ha and 1.60 lakh ha, respectively (Anon 2012). Lower productivity and quality of groundnut and onion was attributed to poor soil health as a consequence of continuous use of synthetic fertilizers. Imbalanced use of fertilizers results in reduction in crop yields. At this critical juncture there is an urgent need to optimize nutrient recycling to sustain crop production without affecting soil health and protection of environment from pollution. Adaption of organic crop production ensures the quality and sustainability of crops. The small and marginal farmers may take up production of liquid manures, viz. vermiwash, panchagavya, biodigested liquid manures which are known to impart multiple benefits of enhancing and sustaining the crop yields. Karnataka is one of the south-western Indian states where agrarian distress is a major problem

due to stagnation in crop yields coupled with increased input costs, reduced farm income and growing debts of farmers. There is an urgent need to intervene for sustaining productivity of farming systems in Karnataka. One adopted strategy to stabilize agriculture production in the state is promotion of organic farming, which is less dependent on external inputs. In the present study an attempt has been made to prepare the bio-digester liquid manures using on farm available organic wastes and green biomass. Further, enrichment of bio-digester liquid manure is made using 10 per cent pongamia cake to increase the content of nitrogen and phosphorus. The enriched bio-digested liquid manure will provide all the nutrients and can replace the chemical fertilizers and it may produce same or equivalent yield. In addition to these cattle urine, indigenous organic additives like vermiwash, and panchagavya were used as foliar application for improving the productivity because of their growth promoters and micronutrients content. Hence these liquid manures were evaluated for their efficacy on the productivity and quality of produce and soil health in groundnut (*Arachis hypogaea* L.)-onion (*Allium cepa* L.) cropping system.

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MATERIALS AND METHODS

Field experiments were conducted on alfisols during *kharif* and *rabi* seasons of 2010-11 and 2011-12 at ZARS farm GKVK, UAS, Bangalore. The soil was sandy clay in texture (coarse sand 33.2%, fine sand 36.4%, silt 7.4% and clay 23.0%) and classified as Typic *Oxichaplustalf* having pH 5.66 and electrical conductivity 0.13 dS/m in the top 15 cm of soil. The available nitrogen, phosphorus, potassium and sulphur were 244.4, 50.9, 154.0 and 19.8 kg/ha, respectively. The organic carbon content of the soil was 0.47%. The water holding capacity, bulk density and porosity of the surface (0-15 cm) soil were 38.15% on volume basis, 1.47 Mg/m³ and 42.11%, respectively. The experiment was repeated on the same site for two years. The experiment was laid out in Randomized Complete Block Design (RCBD) and the treatments were replicated thrice. The treatment includes three types of organic liquid manures involving biodegested liquid manures, enriched biodegested liquid manures and cow urine along with foliar sprays of panchagavya and vermiwash at 3 per cent and recommended dose of fertilizers for irrigated groundnut and onion. The bio-digested liquid manure was prepared in a 200 litre cement tank by adding 15 kg cow dung, 20 litre cow urine, 30 kg of pongamia green biomass and 100 liters water by continuous stirring. The liquid manure was incubated for a period of 45 days and then applied to soil as per the treatments. Prior to application, biodegested liquid manure was analyzed for its nutrient concentration (0.78, 0.21, 0.27, 0.08, 0.03 and 0.26% N,P,K, Ca, Mg and S, respectively). Similarly, enriched biodegested liquid manure prepared by adding pongamia cake at the rate of 10 per cent to the biodegested liquid organic manures and nutrient concentration of EBDLM was 1.14, 0.27, 0.47, 0.14, 0.05 and 0.30% N,P,K, Ca, Mg and S, respectively. The quantity of liquid manures was calculated based on nitrogen

equivalent and were applied. The TMV-2 (groundnut) at 100 kg/ha and Agrifound light red (onion) at 25 kg/ha was sown in 30 cm × 15 cm and 20 cm × 10 cm inter and intra row spacing, respectively. The groundnut seeds were treated with *Rhizobium* and phosphate solubilizing bacteria (PSB) for groundnut and *Azotobacter* and PSB as above in all the treatments. Panchagavya was prepared by using five products of desi cow. Fresh cowdung (7 kg) and ghee (1 kg) were mixed together and kept in a plastic bucket for two days. The mixture was mixed daily once. On the third day, three litres of cow urine, ten litres of water were added and fermented for 12 days. Then, two litres of curd, two litres of milk, 100 g of yeast, two litres of coconut water, 250 g jaggery and 12 ripe bananas were added and contents were stirred for 15 days thoroughly thrice a day. Afterwards, filtered through a cotton cloth and was used for foliar spray @ 3 per cent. Vermiwash was prepared by dipping adult earthworms in luke warm water for 10 minutes, were applied as foliar spray in the field at the rate of 3 per cent. Panchagavya and vermiwash solutions were prepared by mixing 30 ml of each panchagavya and vermiwash in 1000 ml of water separately. The treatments details for groundnut–onion cropping system is given in Table 1. Three per cent each panchagavya for T₃, T₆ and T₉ and vermiwash for T₂, T₅, and T₈ was sprayed at 30, 60 and 75 DAS. From treatment 1 to 9 were supplied by recommended FYM and vermicompost at 50% each based on N equivalent and T₁₀ received FYM at 10 tonnes/ha (groundnut) and 30 tonnes/ha for onion two weeks before sowing. Recommended dose of fertilizer for the treatment T₁₀ (25:75:37.5 kg N, P₂O₅, K₂O kg/ha for groundnut and 125:50:75 kg N, P₂O₅, K₂O kg/ha for onion) was applied at the time of sowing. Nitrogen was applied in two split doses, viz. 50 per cent as basal, 50 per cent at 30 days after sowing as top dressing with full dose of P and K as basal for onion. The nutrients were

Table 1 Treatments details of groundnut–onion cropping system

Groundnut	Onion
T ₁ : BDLM at 25 kg N equivalent/ha	T ₁ : BDLM at 125 kg N equivalent/ha
T ₂ : BDLM at 25 kg N equivalent/ha +3 sprays of VW at 3%	T ₂ : BDLM at 125 kg N equivalent/ha +3 sprays of VW at 3%
T ₃ : BDLM at 25 kg N equivalent/ha + 3 sprays of PG at 3%	T ₃ : BDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3%
T ₄ : EBDLM at 25 kg N equivalent/ha	T ₄ : EBDLM at 125 kg N equivalent/ha
T ₅ : EBDLM at 25 kg N equivalent/ha + 3 sprays of VW at 3%	T ₅ : EBDLM at 125 kg N equivalent/ha + 3 sprays of VW at 3%
T ₆ : EBDLM at 25 kg N equivalent/ha + 3 sprays of PG at 3%	T ₆ : EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3%
T ₇ : CU at 25 kg N equivalent/ha	T ₇ : CU at 125 kg N equivalent/ha
T ₈ : CU at 25 kg N equivalent/ha + 3 sprays of VW at 3%	T ₈ : CU at 125 kg N equivalent/ha + 3 sprays of VW at 3%
T ₉ : CU at 25 kg N equivalent/ha + 3 sprays of PG at 3%	T ₉ : CU at 125 kg N equivalent/ha + 3 sprays of PG at 3%
T ₁₀ : Rec.FYM at 10 t+ 25:75:37.5 kg N:P ₂ O ₅ :K ₂ O/ha	T ₁₀ : Rec.FYM at 30 t+ 125:50:75 kg N:P ₂ O ₅ :K ₂ O/ha
BDLM : Bio-digested liquid manure applied at 20 & 60 DAS	BDLM : Bio-digested liquid manure applied at 20, 60 & 90 DAS
EBDLM : Enriched bio-digested liquid manure applied at 20 & 60 DAS	EBDLM : Enriched bio-digested liquid manure applied at 20, 60 & 90 DAS
CU : Cow urine applied at 20 & 60 DAS	CU : Cow urine applied at 20, 60 & 90 DAS
VW : Vermiwash sprayed at 30, 60 and 75 DAS	VW : Vermiwash sprayed at 30, 60 and 75 DAS
PG : Panchagavya sprayed at 30, 60 and 75 DAS	PG : Panchagavya sprayed at 30, 60 and 75 DAS

applied in the form of urea, single super phosphate and muriate of potash.

The soil samples (0-15 cm depth) were collected at the end of the cropping cycle and analyzed for organic carbon, available N, P, K, S, and bulk density water holding capacity, porosity and soil microbial biomass by the standard methods. The quality parameters like oil yield and protein yield of groundnut and total soluble solids, reducing, non-reducing sugar, ascorbic and pyruvic acid of onion were estimated by adopting standard methods.

RESULTS AND DISCUSSION

Soil chemical fertility

Organic carbon content (SOC) and available nitrogen, phosphorus, potassium and sulphur increased in the soil over the years in groundnut and onion cultivation in sequence. Significantly higher SOC, available nitrogen, phosphorus, potassium and sulphur (0.63%, 355.1, 78.3, 190.8 and 36.3 kg/ha, respectively) was noticed with T₆ and it was followed by T₅ (0.61%, 342.6, 75.3, 187.1 and 32.7 kg/ha, respectively) and T₄ (0.60%, 324.9, 72.1, 185.2 and 32.2 kg/ha, respectively) (Table 2). Significantly higher SOC with T₆ was attributed to the contribution of carbon to soil through EBDLM. Rajnish and Subhash (2011) observed that SOC was 13 per cent higher with organic nutrient management (0.91%) than with synthetic fertilizer use (0.80%). Further, significantly higher available nutrients with T₆ was attributed to slow release of nitrogen from organics might have reduced the N loss from soil since organic carbon in the soil is higher than that from inorganic fertilizer application. High available soil phosphorus could be attributed to increased solubility of native P by means of organic acids produced during the course of decomposition. The increase in available potassium might be related to release of K from EBDLM and also to the solubilisation of mineral bound K or native K.

Soil microbial population

Significantly higher population of bacteria (34.58 × 10⁶ CFU/ g of soil), fungi (21.77 × 10³ CFU/g of soil) and actinomycetes (11.28 × 10³CFU/g of soil) was found with T₆ as compared to the recommended practice (T₁₀) (bacteria 19.77 × 10⁶ CFU/ g of soil, fungi 9.50 × 10³ CFU/g of soil and actinomycetes 5.44 × 10³CFU/ g of soil) but was on par with T₅ (Table 2). The variation in the microbial activity may be due to variation in the organic carbon and rate of decomposition in different treatments. Addition of enriched biodigested liquid organic manure alone or in combination with foliar application of panchagavya or vermiwash was highly beneficial in improving bacteria, fungi and actinomycetes population in the soil.

Yield and sustainability yield index

Pooled results showed that, application of EBDLM at 25 kg N equivalent/ ha + 3 sprays of PG at 3% produced significantly higher pod yield and sustainability yield index of groundnut (2 335 kg/ ha and 0.90 , respectively) followed by EBDLM at 25 kg N equivalent/ ha + 3 sprays of VW at 3% (2 284 kg/ha and 0.88 , respectively), EBDLM at 25 kg N equivalent/ha (2 174 kg/ha and 0.83, respectively) and BDLM at 25 kg N equivalent/ha + 3 sprays of PG at 3% (2 142 kg/ha and 0.82, respectively) than all other treatments. Significantly lower pod yield and sustainability yield index of groundnut (1 603 kg/ha and 0.59, respectively) was observed with recommended practice (Table 3). The increase in yield in BDLM and EBDLM along with three sprays of panchagavya and vermiwash at 3 per cent may be due to biodigested liquid manures and its enrichment with pongamia cake which contributed secondary and micronutrients along with major nutrients besides improving the soil condition, which enhanced the root proliferation and source to sink relationship. Foliar application of panchagavya and vermiwash readily supplied nutrients and growth hormones, viz. IAA and GA present in panchagavya

Table 2 Effect of organic crop production techniques on the chemical and biological fertility of the soil (Pooled data of two years)

Treatment*	Organic carbon content (%)	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)	S (kg/ha)	Bacteria (10 ⁶ CFU/g soil)	Fungi (10 ³ CFU/g soil)	Actinomycetes (10 ³ CFU/g soil)
T ₁	0.56	309.9	69.2	163.3	29.4	27.49	16.06	9.75
T ₂	0.57	312.9	69.8	174.3	30.9	31.40	16.53	9.92
T ₃	0.58	314.0	70.5	177.1	31.3	32.20	19.07	10.01
T ₄	0.60	324.9	72.1	185.2	32.2	32.78	19.80	10.78
T ₅	0.61	342.6	75.3	187.1	32.7	33.69	21.27	10.94
T ₆	0.63	355.1	78.3	190.8	36.3	34.58	21.77	11.28
T ₇	0.50	274.4	59.5	155.1	28.1	25.88	15.25	9.06
T ₈	0.51	285.3	63.0	157.5	28.8	26.75	15.50	9.41
T ₉	0.52	289.4	64.1	159.7	29.2	27.31	16.50	9.57
T ₁₀	0.49	268.4	59.5	155.8	23.5	19.77	9.50	5.44
SEm±	0.01	10.88	1.14	4.54	1.32	0.78	0.75	0.40
CD (P=0.05)	0.04	31.19	3.28	13.50	4.05	2.35	2.15	1.25

* The treatments are as per the details given in Table 1. Initial soil status : OC:0.47% N = 244.4 kg/ha ; P₂O₅ = 50.9 kg/ha ; K₂O = 154.0 kg/ha; S = 19.8 kg/ha , Bacteria: (11.0 × 10⁶ CFU g/soil); Fungi: (7.0 × 10³ CFU g/soil); Actinomycetes: (4.0 × 10³ CFU g/soil)

Table 3 Effect of organic crop production techniques on the yield and sustainability yield index of groundnut–onion in the sequence (Pooled data of two years)

Treatment*	Pod yield of groundnut (kg/ha)	SYI	Bulb yield of onion (tonnes/ha)	SYI	SYI of groundnut–onion cropping system
T ₁	2 080	0.79	30.47	0.70	0.71
T ₂	2 097	0.80	32.63	0.76	0.76
T ₃	2 142	0.82	32.99	0.77	0.77
T ₄	2 174	0.83	34.96	0.82	0.82
T ₅	2 284	0.88	36.01	0.85	0.85
T ₆	2 335	0.90	37.78	0.89	0.90
T ₇	1 738	0.65	26.60	0.60	0.60
T ₈	1 906	0.72	29.12	0.67	0.67
T ₉	2 012	0.76	30.30	0.70	0.71
T ₁₀	1 603	0.59	25.59	0.57	0.57
SEm±	86.1		1.56		
CD(P=0.05)	247.0		4.46		

* The treatments are as per the details given in Table 1

might have stimulated the production of growth regulators in cell system (Somasundaram 2003). The significant effect of panchagavya was mainly attributed to its nutrient content, higher biological activity and presence of plant growth promoting substances, which was confirmed by Hazarika *et al.* (2006). Application of organic manures over a period of time brings more sustainability to the system. Sustainability of the system production was in confirmation with the findings of Jat *et al.* (2011).

Pooled results registered significantly higher bulb yield and sustainability yield index was with the application of EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3% and it was on par with EBDLM at 125 kg N equivalent/ha

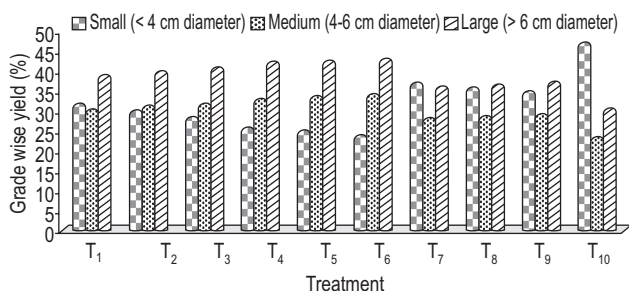
+ 3 sprays of VW at 3% (36.01 tonnes/ha and 0.85, respectively) and EBDLM at 125 kg N equivalent/ha (34.96 tonnes/ha and 0.82, respectively) (Table 4). However, these treatments were significantly superior to adoption of recommended practice (FYM 30 tonnes + 125:50:75 kg N:P₂O₅:K₂O/ ha) (25.59 tonnes/ha and 0.57, respectively). High yields obtained with EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3% (T₆), EBDLM at 125 kg N equivalent/ha + 3 sprays of VW 3% (T₅) and EBDLM at 125 kg N equivalent/ha (T₄) could be attributed to significantly superior yield components, viz. neck diameter, bulb diameter, bulb length, bulb size index. Significant increase in the yield and yield components with the application of EBDLM along with panchagavya and vermiwash spray as against recommended practice might be due to more supply of GA, auxins and other growth promoting hormones with EBDLM and panchagavya spray.

Quality of crops

Quality parameters, viz. oil yield and protein yield of groundnut were significantly higher (875 and 364 kg/ha, respectively) with the application of EBDLM at 25 kg N equivalent/ha + 3 sprays of PG at 3% as compared to other treatments (Table 4). This may be attributed to higher kernel yield with higher oil and protein content. This is in conformity with the findings of Naveen Kumar (2009). Total soluble solids, reducing and non-reducing sugars of onion bulb were higher with EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3% (16.93, 3.66 and 8.66%, respectively) as compared to other treatments (Table 4). Higher ascorbic and pyruvic acid (25.27 mg/100 g and 12.82 µ moles/g) content in onion bulbs was noticed with EBDLM at 125 kg N equivalent/ha + 3 sprays of PG at 3% as compared to other treatments. Higher reducing and non-reducing sugars, ascorbic and pyruvic acid content of the onion might be due to the presence of essential plant nutrients in EBDLM and panchagavya and plant growth regulatory substances which might have improved the quality characters

Table 4 Effect of organic crop production techniques on the quality of groundnut–onion in the sequence (Pooled data of two years)

Treatment*	Groundnut		Onion				
	Oil yield (kg/ha)	Protein yield (kg/ha)	TSS (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100 g)	Pyruvic acid (µ moles/g)
T ₁	658	285	15.07	3.51	8.05	23.33	12.35
T ₂	685	288	15.09	3.53	8.06	23.96	12.36
T ₃	713	298	15.23	3.55	8.07	24.11	12.40
T ₄	740	309	15.42	3.63	8.25	24.28	12.44
T ₅	828	345	15.78	3.64	8.55	24.71	12.47
T ₆	875	364	16.93	3.66	8.66	25.27	12.82
T ₇	499	209	12.72	3.32	7.31	23.19	11.37
T ₈	595	244	13.96	3.47	7.85	23.31	12.31
T ₉	642	263	14.38	3.46	8.02	23.32	12.33
T ₁₀	384	160	12.36	3.18	6.94	20.68	11.32
SEm±	46	22	0.64	0.07	0.21	0.66	0.16
CD (P=0.05)	136	65	1.88	0.19	0.61	1.94	0.45



* The treatments are as per the details given in Table 1

Fig 1 Per cent yield of different grades of onion as influenced by different liquid organic manures

of onion. Singh and Singh (1968) also found that application of panchagavya and bio-digester foliar sprays at cob formation in maize enhanced the protein and carbohydrates content. Higher per cent of medium (4-6 cm diameter) and large (> 6.0 cm diameter) sized bulb yield (33.90 and 42.69%, respectively) was recorded with EBDLM at 125 kg N equivalent/ ha + 3 sprays of PG at 3% as compared to other treatments (Fig 1). The increase in large and medium size bulbs with EBDLM/BDLM along with PG was due to balanced availability of nutrients and better root development leading to increase in photosynthates and their translocation and accumulation in the bulbs. These results are in line with those of Hussaini and Amnas (2000).

Application of Enriched biodigested liquid manure at 25 kg N equivalent/ha for groundnut and Enriched biodigested liquid manure at 125 kg N equivalent/ha for onion in combination with three sprays of panchagavya (3%) was found superior in groundnut-onion cropping system to produce crops with superior quality, higher and sustainable productivity besides maintaining soil health.

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